Helium Isotopes in hot Springs and (hot) Wells of the Basin and Range

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The Basin and Range (BR), a major tectonic province of the western margin of the North American plate, is characterized by an anomalous thermal gradient, large heat flux, high regional elevation, and volcanism and extensional tectonics that have varied in time and space. He isotopes provide a definitive distinction between crustal and magmatic fluid sources and in the case of crustal fluids, allow an evaluation of the presence, size, and involvement of mantle melts; important factors for understanding tectono-magmatic processes and their influence on BR evolution. Since elevated ^{3}He fluxes, as measured by He isotope compositions, reflect mantle melting, He isotopes provide constraints on models for regional high heat flux anomalies, such as lithospheric stretching accompanied by accretion of crystalline mantle, thinning accompanied by accretion of mantle melts, or thinning associated with intrusions of mantle melts into the upper crust. To evaluate these models, we are in the process of constructing a He isotope 'map' of the greater BR. Fluids from the western margin of the BR have He isotope ratios as high as 6-7 Ra, indicating upper crustal intrusion of mantle melts consistent with recent and current volcanism. Moving away from these areas, He isotope ratios decrease rapidly to 'background' values of around 0.6 Ra, and then gradually decrease eastward to low values of 0.1 Ra at the eastern margin of the BR. Assuming a steady-state relationship for the transport of heat and He through the crust, such low ratios are inconsistent with regional underplating or intrusion by mantle melts into the upper crust. Superimposed on this regional trend are isolated features with elevated He isotope ratios (0.8-2.1 Ra) compared to the local background. Spring geochemistry and local geology indicate that these 'He-spikes' are not related to current or recent magmatic activity, suggesting that the spikes may reflect either small localized zones of deep mantle melting or deep permeable pathways (faults) with high vertical fluid flow rates. A detailed study of one of the He-spikes (Dixie Valley and the Stillwater Range Front Fault system), indicates that features with high He isotope ratios are confined to the range front normal faults characteristic of the extensional regime in the BR, suggesting that such faults can be permeable pathways for deep fluid circulation.